2.4 High Data Rate MWD Mud Pulse Telemetry

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Abstract

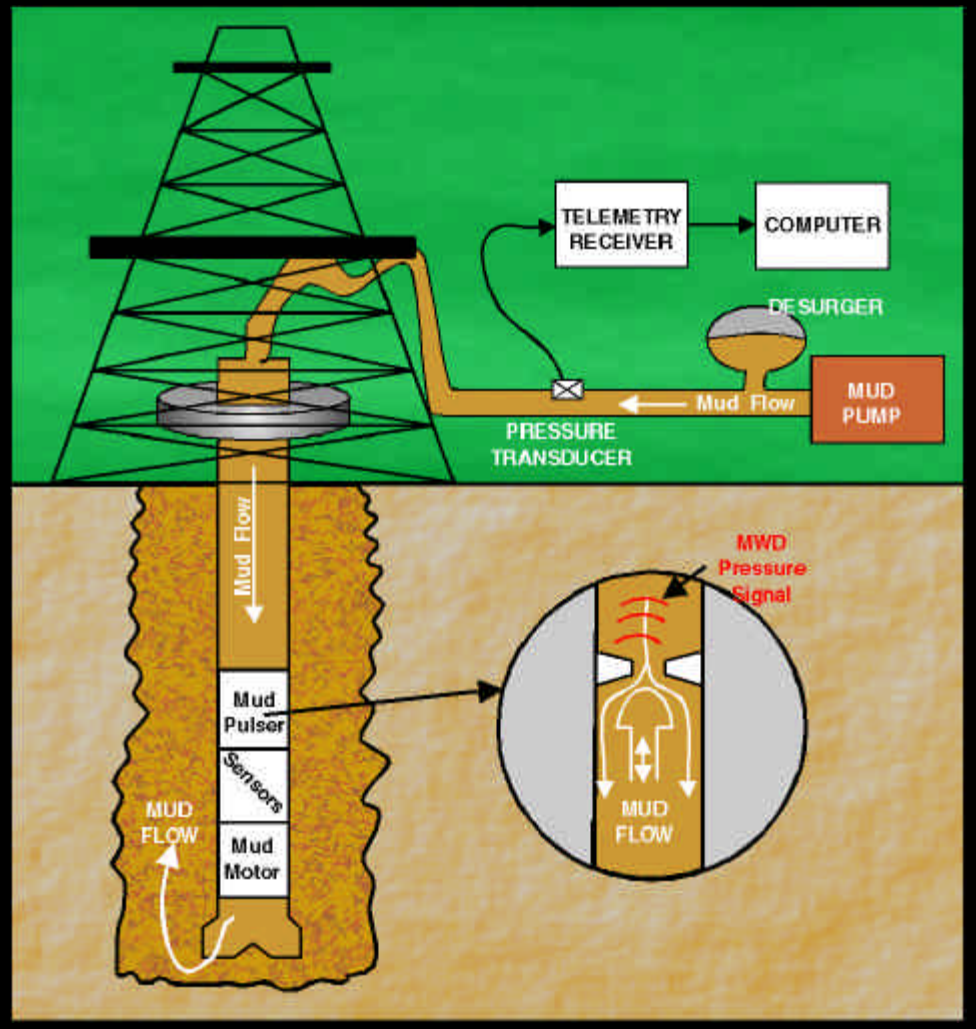
The objective of this project is to build and test a research prototype of a 20-30 bits/ second MWD mud-pulse telemetry system. At current telemetry rates of 1-3 bits/seconds, the driller must be very selective about what drilling data is transmitted. This lack of information makes is more difficult to optimize the drilling of wells. Halliburton has demonstrated that a 30 bits/second mud-pulse can be recovered in a 10,000 foot flow loop.

HIGH DATA RATE MWD
MUD PULSE TELEMETRY

U.S. Department of Energy's
Natural Gas Conference
Houston, Texas
March 25, 1997

Wally Gardner
Halliburton Energy Services

MUD PULSE TELEMETRY SYSTEM



CURRENT MWD TELEMETRY

- **Mud Pulse (All Types) 1-3 Bits/Sec**
- **Electromagnetic (in 1-5 ohm-m) 1 Bits/Sec**
- **Acoustic Not Commercial**
- **Hard-Wired Drill Pipe Not Commercial**

Note: Data Compression, Not Included Above, Could Increase Data Rates an Additional 3x.

PROJECT GOAL: 20-30 BITS/SEC

- Characterize Mud Pulse Transmission and Drilling Noise
- Develop Mud Pulsers for 20-30 Bits/Sec
- Develop Receivers and Advanced Signal Processing
- Demonstrate Working Pulser/Receiver System at 20-30 Bits/Sec

WORK PLAN

- Phase 0 (Jun 94 - Jan 95)
  - Halliburton Research of Concepts
  - Proved 30 bps is Possible
- Phase 1 (Jan 95 - July 97)
  - Present GRI/Halliburton Joint Project
  - Build a Working 20-30 bps Pulser/Receiver
- Phase 2 (1998+)
  - Future GRI/Halliburton Joint Project
  - Develop into a Commercial System

PHASE 1: CURRENT PROJECT

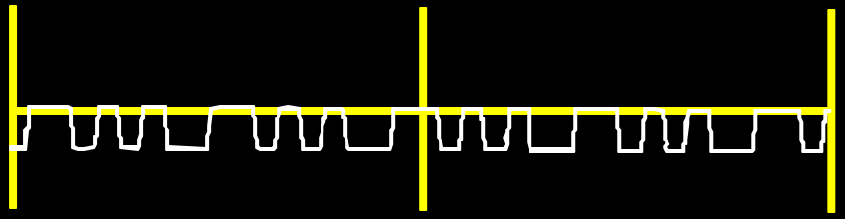
- Major Tasks
  - Refine Pulser Concept Options
  - Collect and Analyze Drilling Noise Data
  - Develop Receiver and Signal Processing
  - Demonstrate 20-30 bps Transmission
- Enabling Technologies
  - Low-Power High-Rate Pulser
  - Knowledge of Mud Transmission Channel
  - Advanced Digital Signal Processing
  - Flow Loop for System Testing

WHERE WE ARE TODAY

- Two High-Rate, Low-Power Pulsers
- Acoustic Model of Mud Transmission Properties and Drilling Noise
- Tested Advanced Signal Processing Algorithms
- Transmitted and Received 30 bps in LSU and Houston Flow Loop, Processing Data from Memory
- Developing Real-Time Receiver & Algorithms
- Completed 11,000 ft Houston Flow Loop for System Testing
- Also Use 10,000 ft Flow Loop at LSU

ADVANCED LWD TELEMETRY
30 BIT/SECOND DATA RATE TESTS

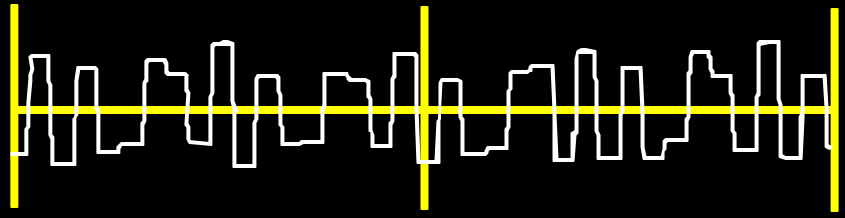
DOWNHOLE SIGNAL



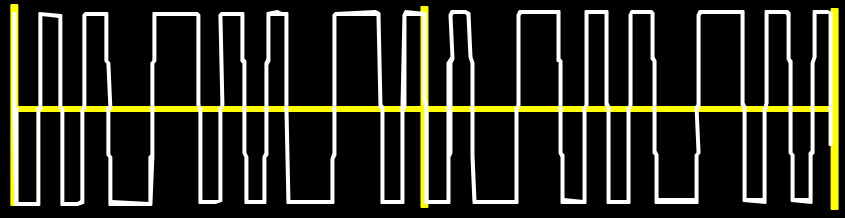
10,000 FT LSU FLOW LOOP

(12# MUD - NO DRILLING NOISE)

AFTER INTERMEDIATE SIGNAL PROCESSING



FINAL SIGNAL OUTPUT



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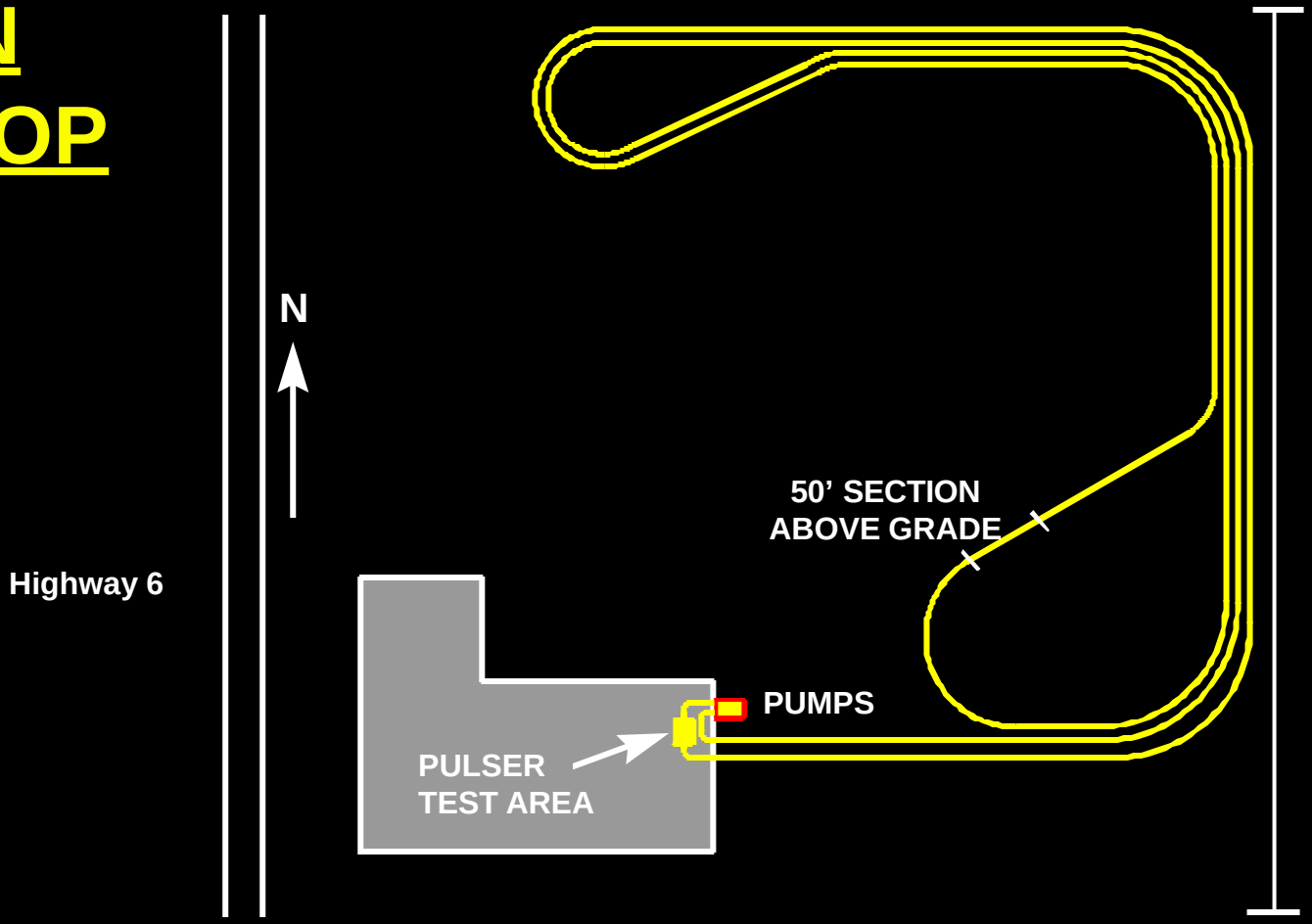
HOUSTON FLOW LOOP

- Located at Halliburton's Houston Technology Center (West Houston)
- 11,000 ft, World's Longest MWD Flow Loop
- 3.5-in. OD, 3.1-in. ID Coiled Tubing
- National Oil Well A-1100PT Triplex Pump
  - 700 gpm at 1300 psi
- Cost $125,000
  - GRI Share $22,500
- Construction Completed April 1996

HOUSTON FLOW LOOP



Halliburton Flow Loop Construction

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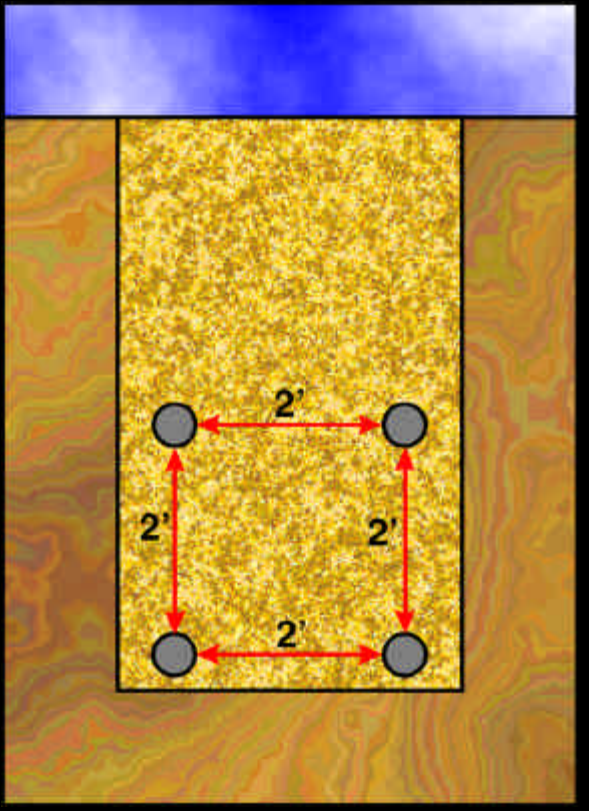

WHERE WE ARE GOING

- Test Alternate Pulsers
- Expect to Complete Research (Phase 1) in 1997
- Expect to Start Development (Phase 2) in 1998
- Flow Loop Testing of the Integrated System: Pulser/Receiver/Signal Processing Software

BENEFITS TO GAS PRODUCERS

- Wireline Log Replacement
  - Benefit is Reduced Drilling Costs
- More Real-Time MWD Data
  - Better Pay Zone Steering, Drill More Productive Wells
  - Better Able to Drill Thin, Marginal Sands
  - Downhole Drilling Sensors Improve Drilling Decisions

WIRELINE LOGGING COSTS - 1995

- Offshore
  - Logging Invoices $ 450 million
  - Rig Time Cost $ 200 million
- Land
  - Logging Invoices $ 720 million
  - Rig Time Costs $ 130 million
- LWD Can Eliminate the Rig Time Cost of WL Logs in Many Development Wells
- Wireline Replacement in 25% of Offshore Wells Will Save Oil Companies $50 million/yr

MORE REAL-TIME DATA

- WL Cable Telemetry Rates Kept Up With Acquisition Rates:

	Acquired	Cable Telemetry
1970	50 bps	5 kbps
1980	200 bps	80 kbps
1985	20 kbps	120 kbps
1995	100 kbps	750 kbps
2000	350 kbps	1 mbps (est.)

- Telemetry is Already a Major Limiting Factor in Application of MWD Technology (1-3 bps)
- Currently Acquire Over 150 bps of MWD Data, Must Choose Which to Transmit

BETTER PAY ZONE STEERING

- Data From Near/At-Bit Sensors Support the Steering of Boreholes into Thin Targets
  - Coupled with Horizontal Drilling, This Becomes an Enabling Technology
  - Makes Commercial Targets From Many BCF of Currently Marginal Gas Reservoirs
  - Higher Data Rates Provide More LWD Data, Better Decision Support at Rig
- Limited by Telemetry:
  - Imaging While Drilling
  - Magnetic Azimuth Corrections

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IMPROVED DRILLING

- At-Bit Sensors Enable Close Monitoring of the Drilling Process
  - Monitor Annulus Pressure
  - Detect Bit Stick & Whirl, Excessive Vibration
- Drilling ‘Problems’ Add 30% to Total Drilling Cost of Typical Well
  - Potential to Reduce These by Just 10% by Early Detection by BHA Sensors
  - Reduction of Total Drilling Costs by 3%

BENEFITS TO MWD INDUSTRY

- Increased Use for Wireline Replacement
  - Every 5% Additional Replacement is an Additional $ 50 million/yr Revenue
- Increased Use of Additional Sensors
  - Resistivity-GR-Directional Has Become Standard
  - Value of Data is Partly Lost if Only Stored Due to Inadequate Telemetry
  - Expect 50% Increase in Use of Porosity & Other Sensors, Additional $ 25 million/yr
- Increased R&D Spending by MWD Industry
  - Increase of $75 Million in Revenue Will Result in Additional $5 Million/yr (6%)

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Available Logging Technology - 1960

- Single Induction Electric/Short Normal/SP
- Microlog
- Single Laterolog
- Density (uncompensated)
- Neutron (uncompensated)
- Sonic (uncompensated)
- Gamma Ray
- Caliper
- Dip Meter (3-arm)
- Percussion Cores

Total Data Acquired: 45 kb/1000 ft

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Available Logging Technology - 1970

- Dual Induction Laterolog/SP
- Microlog
- Single Laterolog
- Density (uncompensated)
- Neutron (uncompensated)
- Epithermal Neutron (uncompensated)
- Sonic (compensated)
- Gamma Ray
- Caliper
- Dip Meter (3-arm)
- Formation Tester (samples only)
- Percussion Sidewall Cores

Total Data Acquired: 51 kb/1000 ft

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Available Logging Technology - 1980

- Dual Induction Focussed Laterolog/SP
- Microlog
- Dual Laterolog/MSFL
- Density (with photoelectric measurement)
- Neutron (compensated)
- Epithermal Neutron (uncompensated)
- Sonic (compensated or long-spaced)
- Gamma Ray
- Dip Meter (4-arm)
- Dielectric Logging (high- and low-frequency)
- Formation Tester (samples and pressures)
- Percussion Sidewall Cores
- Primitive Borehole Televiewers

Total Data Acquired: 160 kb/1000 ft

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Available Logging Technology - 1985

- High Resolution Induction/Dual Induction Focussed Laterolog/SP
- Microlog
- Dual Laterolog/MSFL
- Density (with compensated photoelectric measurement)
- Neutron (compensated)
- Epithermal Neutron (compensated)
- Sonic (full waveform digital)
- Spectral Gamma Ray
- Dip Meter (6-arm)
- Electric Resistivity Imaging (1-pad)
- Dielectric Logging (high- and low-frequency)
- Formation Tester (samples and pressures)
- Rotary Sidewall Cores
- Percussion Sidewall Cores
- More Advanced Borehole Televiewers

Total Data Acquired: 3 Mb/1000 ft

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Available Logging Technology - 1993

- High Resolution Induction/Dual Induction Focussed Laterolog/SP
- Microlog
- Dual Laterolog/MSFL
- Density (with compensated photoelectric measurement)
- Neutron (compensated)
- Epithermal Neutron (compensated)
- Sonic (full waveform digital)
- Spectral Gamma Ray
- Dip Meter (6-arm)
- Electric Resistivity Imaging (6-pad)
- Dielectric Logging (high- and low-frequency)
- Formation Tester (samples and pressures)
- Rotary Sidewall Cores
- Percussion Sidewall Cores
- Digital Borehole Televiewers

Total Data Acquired: 60 Mb/1000 ft

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